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The deep water fisheries of the Rockall trough; some insights gleaned from Irish survey data.

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ABSTRACT

The Fisheries Research Centre (FRC) has conducted trawl and longline surveys in the Rockall Trough since 1993, fishing a total of 223 stations over the depth range 201 to 2,925m. Trawls produced greater species diversity and higher discard rates than longlines, which selected larger squaliform sharks. In 1997, limited selectivity work, based on ten comparative tows, showed that the size range of roundnose grenadier (*Coryphaenoides rupestris*) caught using a commercial trawl (110mm), with and without a small mesh end liner (30mm), were similar. This indicates that mesh size because of poor selectivity and perceived low survival rates of escapees, may not be a useful management tool in the regulation of the trawl fishery. Preliminary age estimates from a number of selected species in the catch ranged from 2-60 years (*C. rupestris;* Bairds smoothhead, *Alephcephalus bairdi* and black scabbard, *Aphanopus carbo;* greater forkbeard, *Phycis blennoides;* bluemouth rockfish *Helicolenus dactylopterus)* and support the notion that many deep-water species are long lived. The surveys also highlighted the absence of certain life cycle stages in the catches; all black scabbard were immature fish; no *Centrophorus squamosus* or *Deania calceus* less than 70cm, nor any gravid females of these species were taken on any of the surveys. In addition, a number of rare chondrichthian species *(Hydrolagus pallidus, Raja kukujevi, Bathyraja richardsonii* and *Bathyraja pallida*) and species not normally associated with the Rockall Trough (*Centrophorus uyato*, and *Raja hyperborea*) were identified from the surveys.

INTRODUCTION

Developing technology and declining traditional shelf dwelling fish stocks has lead to the exploitation of deep water (400-1,500m) fish in the north east Atlantic (Hopper, 1995). The main countries exploiting the fishery are France, Norway, Iceland, Faroes and the UK. In 1997, an estimated 27,000 tonnes of deep-water fish were landed from Sub Areas VI (the Rockall Trough) and VII (Anon. 1998a). Markets exist in France, Spain and the US and this is now a valuable fishery. Indications are that deep-sea species are being heavily exploited, with limited management measures in place (some EU effort restriction) and little known about their basic biology. This has given rise to concerns within the scientific community (Hopper, 1995; Aikman, 1997)

Research on deep-water fishes began towards the end of the last century. The first expedition from Ireland was launched in 1885 by the Royal Irish Academy with the *Lord Bandon* and continued through to 1888 with the same boat under a different name *Flying Falcon* (Went, 1978). These surveys covered deep-water to the West and South of Ireland. In its survey of commercial fishing grounds off the West Coast of Ireland the Royal Dublin Society made occasional reports of deep-water species taken by the two chartered fishing vessels the *Fingal* and the *Harlequin* in 1890 and 1891 (Holt & Calderwood, 1895). The department of Agriculture and Technical Instruction took over the role of the Royal Dublin Society in 1899 and a series of investigations of the fish fauna of the Irish Atlantic slope was undertaken between 1905 and 1910 on the *Helga* (Holt & Byrne, 1905; 1906; 1908; 1910; 1912; Farran, 1924). The accounts of the *Helga* are a valuable source of reference material (specimens and survey reports) from an Irish context. In their series of investigations Holt & Byrne record some 103 species of deep-water fish from the Irish Atlantic slope and provide detailed taxonomic descriptions of several species. The families Scorpaenidae, Alepocephalidae, Chimaeridae, and the genus Myctophum are particularly well covered. Massy (1909, 1928) provides taxonomic descriptions of cephlapods taken on these surveys.

No Irish further studies were carried out in deep-water until the introduction of large pelagic vessels to the Irish fleet in the mid 1980's. Argentines (*Argentina silus*) were the focus of exploratory fishing, carried out by both Irish and Dutch vessels from 1988-1991, in the deep-waters to the west of Ireland and Scotland. Bord Iascaigh Mhara (BIM) began the first deep-water fishing trials in 1988 under the EU Exploratory Fishing Voyage scheme. The objective was to divert effort from existing quotas species and the trials were targeted at blue whiting (*Micromistius poutassou*) and *A. silus*, principally in ICES area VIa-b and VIIb-c (McCormick, 1995; Connolly & Kelly, 1996a).

During 1991-1993 the Irish exploratory fishing programme shifted to demersal trawling with a wider range of species being caught, including *C. rupestris*, *A. carbo*, and Portuguese shark (*Centroscymnus coelolepis*) (McCormick, 1995). However, with poor commercial catch rates, extensive gear damage and problems with marketing of the catch, the fishery produced a poor economic return.

In the early 1990's the focus of European deep-water research began to shift from exploitation, species description and distribution, to studies on the life history, population dynamics and ecology of deep-water fish (Bergstad, 1995). In line with these developments, the Fisheries Research Centre (FRC) commenced a deep-water sampling programme, in the Rockall Trough in 1993, funded primarily by the EU STRIDE initiative. To date eight research surveys have focused on 5 areas in the Rockall Trough (Figure 1) over the depth range 500m to 2,925m (Connolly and Kelly, 1994; 1997; Kelly *et al.* 1997b; Connolly *et al.* 1998; Clarke *et al.* 1998; Connolly, 1997; Clarke, 1997). The main objective of these surveys has been to assess the abundance and distribution of deep-water species, carry out preliminary discard work and to secure samples for the life history programme and a food quality programme. This work has been published in (Gormley *et al.* 1994; Kelly *et al.* 1996; Connolly and Kelly 1996b; Kelly *et al* 1997a; Maier *et al.* 1997). In addition a new programme on contaminants analyses commenced in 1998. This is a result of deep-water fish species from the west of Ireland, including the Rockall Trough, playing an increasingly important role in the human food chain. Only a limited number of studies addressing the concentration of contaminants in deep-water shark and fish have been reported (Cross *et al.*, 1973, Leatherland *et al.*, 1973, Vas *et al.*, 1993, Vas and Gordon, 1993).

The Scottish Association for Marine Science (SAMS) began a long-term study on the ecology of the pelagic and benthic fauna of the Rockall Trough in 1976 and the bathymetric distribution and feeding ecology of many deep-water benthopelagic species is reviewed in and Gordon & Swan (1993)Gordon (1986).

The discarding at sea of fish harvested from the oceans and its associated mortalities have been recognised and noted as inherent problems in fisheries management since early this century (Alverson *et al.* 1994). In the last decade there has an explosive interest in the documentation and search for solutions to the by-catch and discard problem with global discarding in 1992 estimated at 27 million tonnes (Alverson *et al.* 1994). There has been limited published work on discarding from commercial deep-water fisheries and published reports indicate that overall discards may be small compared with other shelf fisheries (Connolly and Kelly, 1996a). In some prawn trawl fisheries, discard rates of 10-15kg per kg landed are not uncommon (Bjordal and Lokkeborg, 1996). However, the impact of discard activities on the fragile deep-water ecosystem, even if at a comparatively low level, may be significant.

This paper presents a brief overview of Irish deep-water surveys with emphasis on the most recent programme conducted in the Rockall Trough. The results of preliminary discard and selectivity work are presented, together with some of the main results from investigations on the life history of some of the dominant species taken in the catches. The impact of commercial fishing activity on the deep-water ecosystem is discussed.

MATERIALS AND METHODS

The target area for the deep-water trawl and longline surveys was in the continental slope area, north of 50° N and south of 58° N (ICES Divisions VIa, VIIb, VIIj), over the depth range 500 to 1,200m. The selection of specific target areas and suitable trawl positions was of paramount importance to the success of the surveys and a considerable amount of time was devoted to collating data on potential tow positions, fishing grounds and the analyses of available catch information (Bridger 1978, Ehrich 1983). The prime consideration was to locate safe tows which would minimise gear damage, yield good catches of a variety of deep-water species and survey as wide an area as possible (Connolly and Kelly, 1994). A list of the surveys undertaken are given in Table 1 while the location of the station positions from trawl and longline fishing operations are given in Figure 1.

Details of the protocols used for species identification, analysis of the catch and discards, and the methods used for age estimation can be found in Connolly and Kelly (1994; 1996a; 1996b; 1997); Kelly *et al.* (1997b) and Clarke *et al* (1998). Maturity stages of squaliform sharks were based on Stehmann (1994).

RESULTS

Details of the various trawl and longline surveys undertaken by the FRC over the period 1993 top 1997 are given in Table 1 while the location of the stations fished in the Rockall Trough are shown in Figure 1. The areas fished in the Rockall Trough proved very suitable for trawling operations with limited gear damage sustained over a generally soft and level bottom.

The species composition of the trawl and longline catches was very different in terms of size and reflected the fundamental difference in the two methods of fishing. Squaloid shark dominated the longline catches and teleost species dominated the trawl catches. Details of the trawl and longline catches taken during all the surveys are given in Table 2. A total of 669 hours were trawled during the surveys, yielding a total catch of 236 tonnes and discards of 93 tonnes (39% of catch discarded). The most abundant species present in the trawl catch were *C. rupestris* (92.4t) and *A. bairdi* (37.8t) while the most abundant species in the trawl landings were *C. rupestris* (88.9t) and *A. carbo* (8.8t). A total of 445 hours were fished during longline surveys, yielding a total catch of 35t and discards of 7t (20% of catch discarded). The most abundant species present in the longline catch were the squaloid sharks *C. squamosus* (13.4 t) *Deania calceus* (5.9t) and *C. coelolepis* (5.3t) while the most abundant species in the longline landings were .*C. squamosus* (13.4t) and *C. coelolepis* (5.1t). Shark dominated the longline catches and teleosts dominated the trawl catches (Figure 2). Teleost species which were taken by both gears displayed different size ranges with longlining taking larger specimens of tusk (*Brosme brosme*), blue ling (*Molva dypterygia*), and *P. blennoides*. (Fig. 3). Longline catches of *P. blennoides*. (which exhibit strong sexual dimorphism (Fig. 4)) are dominated by female fish of greater than 45cm. However, for squaloid shark, the size range of male and female for *C. squamosus*, *C. coelolepis* and *D. calceus* are the same for trawl and longline gears (Fig. 5). A notable feature is the sexual dimorphism with respect to length, females tending to be larger in all species. Another feature of the data is the lack of small specimens (< 80 cm) in all three species. However, pups *of C. coelolepis* have been recovered from gravid females. No gravid females have been observed in the other two species. The male and female maturity stages are shown in Fig. 6. A notable feature of the sampling data is the lack of stages 4 to 7 in *C squamosus* and *D. calceus.*

The length frequency distributions (raised catches) of the *A. bairdi*, and *A. carbo* from all surveys conducted by the FRC (1993-1997) are given in Fig. 7. All *A. carbo* examined were immature or early maturing fish and specimens less than 40cm were extremely rare over all surveys. These results are similar to those recorded by Gordon and Swan (1993). The otoliths from 230 *A. carbo* were sectioned and read following the protocols described in Kelly *et al.* (1997a). The otoliths of *A. carbo* show no clear zones when viewed whole. Using very thin sections (0.25-0.35mm) clear zones are visible, however interpretation of these otoliths is difficult due to split zones. Preliminary age estimates ranged from 4 to 32 years of age with most fish in the range 10 to 18 years of age. Preliminary age estimates were also carried out on *A. bairdi* from 80 otolith sections and produced ages ranging from 8 to 28. Analyses of catches indicated that there may be a juvenile nursery area on the southern slope of the Rockall Plateau. *A. carbo* and *A. bairdi* were only recorded in trawl catches.

The length frequency of *P. blennoides* (Fig. 4) indicates that there is a strong sexual dimorphism with males (20 to 45cm) much smaller than females (30 to 75cm,). Preliminary age estimates from 346 otolith sections produced age ranges from 1 to 9 years with modal age of 3 (Fig.8) *P. blennoides* were taken in both trawl and longline catches, however it can be seen from Fig. 3 that longline catches of *P. blennoides* are dominated by female fish of greater than 45cm.

A survey conducted in November 1997 carried out ten repeat tows, with and without a small mesh cod end liner (30mm), on a commercial 105mm trawl, in order to carry out a preliminary examination of *C. rupestris* selectivity (Clarke *et al* 1998). The landings and discards from both operations were measured (Fig 9). These data show two distinct size modes representing the landed (12 to 25cm) and discarded (6 to 16cm) component of the *C. rupestris* catch. The length distributions of the catch are very similar and may indicate that cod end mesh size may not be a useful management tool for this fishery.

DISCUSSION

It is recognised that management measures must be introduced to the developing deep-water fishery and that these should be based on a sound knowledge of the life history of the species (Anon. 1993; Anon 1995; Hopper, 1995). The FRC survey programmes have provided information on discards, selectivity, general life history and made records of unusual chondrichthian species from the deep-water of the Rockall Trough.

Longevity and growth rates are regarded as a vital component of any life history study and devising accurate methods of ageing deep-water species was identified as one of the high priority areas for future research (Bergstad, 1995). Despite the large number of deep-water species aged over recent years much of the work remains in the grey literature (Connolly *et al* 1995) and validation remains a problem. However work reported in Anon (1998b) and Gordon *et al* (1995a) indicate that many deep-water macrourid species have an annular cycle in the banding pattern seen on the otolith. Kosswig & Rubec (1984) have argued that the fine bands seen on the collar of large redfish (*Sebastes mentella*) otoliths should be interpreted as annual zones, based on corroboration from radiometric ages. If these arguments hold for age estimates produced for deep-water species (e.g. *C. rupestris* - up to 60 years; Kelly *et al* 1997a; *H. dactylopterus* - up to 37 years; Kelly *et al* in prep and *A. carbo* - up to 32 years; Anon 1998b) then the belief that they are relatively long lived is confirmed.

The present study produced age estimates for black scabbard of up to 32 years. However Morales-Nin and Sena-Carvalho (1996) have reported *A. carbo* as living only to 8 years in the waters off Madeira. These age estimates were produced from whole otoliths though the higher age estimates produced in this study were from sectioned otoliths. In addition to a relatively high longevity, delayed onset of maturity and low fecundity would also seem to be characteristics of a great number of species inhabiting these depths (Eliassen & Falk-Petersen, 1985; Kelly *et al.*, 1997a; Alekseyev *et al* 1991). Results from Irish surveys have shown maturity in *C rupestris* and *H. dactylopterus* to be 9-11years and 12 -16 years respectively (Kelly *et al* 1997a; Kelly *et al* in prep). Low fecundity is also evident in *C. rupestris* (Kelly *et al* 1996) and squaloid sharks, which are viviparous, have a low pupping level (*C. coelolepis* 16 pups Clarke *et al* 1998, Connolly *et al* 1998) and a gestation period which is estimated at greater than a year (Yano and Tanaka, 1988).

A notable feature of the length frequency of the catch of *A. bairdi* was the length distribution recorded by this study in the Rockall Trough and by Magnusson & Magnusson (1995) on the Reykjanes Ridge. Data from the Reykjanes Ridge show a modal length at 46cm (range 8-65cm), while data from the Rockall Trough show a bimodal distribution (modal lengths 26cm and 75cm) with the length groups from 34 to 64 poorly represented. This suggests that different components of the catch occur in these areas. The length frequency of *A. carbo* was similar to that recorded in the Rockall Trough by Gordon and Swan (1993) and on the Reykjanes Rodge by Magnusson & Magnusson (1995).

Comprehensive knowledge of the life history of many species is still incomplete, e.g. no mature or pupping *C. squamosus* or *D. calceus* have been found in the Rockall Trough. Analyses of black scabbard samples from all surveys carried out by the FRC at different times of the year show no specimens of mature fish. Gordon and Swan (1993) have also reported this lack of mature fish in the Rockall Trough. However these findings are at odds with Nakamura and Parin (1993) and Zilanov & Shepel (1975) who state that black scabbard spawn west of the British Isles from November to April. For some of these species reproducing individuals are found either at the mid Atlantic ridge (*A. carbo*) or further south (*D. calceus*). This fact has led to speculation that individuals of these species found in the Rockall Trough may be undertaking migrations to or from feeding or spawning grounds (Zilanov & Shepel, 1975).

Commercial deep-water trawling activities commenced in the Rockall Trough in the late eighties, and there can be little doubt that this has had a significant impact on the deep-water ecosystem in terms of discards and perturbation of the sediment. It is clear that mobile bottom gears scrape the surface of, or dig into the seabed to varying degrees (Lindeboom & de Groot, 1998). Deep-water fishing activities provide two main sources of food for benthic scavengers. Firstly as food falls that originate from discards and by-catch that are not consumed by seabirds and mid water predators. Secondly as demersal trawls are dragged across the seabed they dig up and displace, damage or kill a proportion of the epi- and infaunal animals in the path of the gear (Lindeboom and de Groot, 1998). In addition, some of the animals caught in the trawl may escape the cod-end and subsequently die. Nevertheless the proportion of carrion material which reaches the bottom and the subsequent fate of such material entering the benthic deep-water ecosystem is still unknown. Most studies to date which have investigated the effects of fishing on benthic communities have been carried out in shallow seas at depths <100m. This is not surprising as the majority of demersal fishing activity occurs in this depth range and as quantitative ecological studies become logistically complex at greater depths. Jones (1992) and Lindeboom and De Groot (1998) have reviewed the environmental impact of trawling. Jones (1992) has identified the paucity of information on the effects of trawling on the deep-sea bed. The continental slope where these deep-sea species are caught has the greatest biodensity and biodiversity of any region of the temperate ocean (Gordon et al., 1995b). In the Rockall Trough, there is a seasonal sedimentation to the deep-seabed which forms ooze, high in silica and calcium carbonate This seasonal vertical flux of organic matter on the seabed is an important biogenic variable of the ecosystem (Gage & Tyler, 1991; Mauchline & Gordon, 1991) and it is possible that impact of trawling on the benthos and the death of both target species and non target biota may affect recruitment and standing crop in deep sea populations.

The FRC survey data have produced some useful preliminary information on discarding and selectivity relating to the impact of trawling on the deep-sea ecosystem. The discard data from 1995 and 1996 has already been published and indicate that in 1995 an estimated 7,530t were discarded in the international deep-water trawl fishery (Connolly and Kelly, 1996). Irish surveys carried out in October 1995 and September 1996 have shown overall discard rates at just under 20% French data over the same period have shown variation from 9-38% (Anon, 1998a). The most recent Irish survey in October 1997 produced discard rates in excess of 70%, this was mainly due to the large numbers of small grenadier caught (Clarke *et al.* 1998). These results are not particularly high in relation to certain shelf fisheries but they do not take into account the fate of escapees.

The survival rates of traditional shelf dwelling species from trawl nets varies according to species (Mains & Sangster, 1990; Soldal *et al* . 1993). However there are no published reports for escapees from deep-water trawling but the general consensus is that survival rates are low (Connolly & Kelly, 1996). In addition it appears that a commercial trawl net (mesh size 105mm) catches a significant proportion of the smallest length classes (3-10cm PAF) of *C. rupestris*. These characteristics of high escapee mortality and poor selectivity suggest that mesh size may not be a good tool in the management of the trawl fishery.

Life history characteristics of many deep-water species indicate that they may be vulnerable at high levels of exploitation. This would be the case if fishing activity covered the entire depth range of the species. However it has been noted at the most recent study group on deep-sea fisheries resources (Anon. 1998a) that some species are only vulnerable to fishing activity over part of their depth range. When that part of the depth range fished by the gear is relatively small, the exploitation pattern on the entire stock may not be significant. If a disturbance (such as fishing mortality) is considered to be analogous to the introduction of a new predator, the effects of this form of predation may be more pronounced since it is not dependent on prey availability (Caswell, 1978). Fishing mortality may be considered as an increase in predation at the summit of the food web. Reduction of top predators between 500m and 1000m and increased inputs of carrion may open new possibilities for colonisation by other competitors. Among deep-water sharks, *C. squamosus* and *D. calceus* are the most susceptible to fishing pressure since they are most abundant in the depth range of the fishery (<1000m) (Gordon and Swan, 1997). *C. coelolepis* may be less susceptible since only the upper stratum of its depth distribution is within the range of normal fishing gears. As most of the trawling in the Rockall Trough is concentrated in the depth range where *C. squamosus,* and *D. calceus* occurs, fishing activity could lead to changes in bathymetric distributions of deeper living species.

Among the unusual species of chondrichthian fish taken during the FRC surveys were those not normally associated with the Rockall Trough, *Raja hyperborea* and *Centrophorus uyato*. In addition a range of specimens of *Bathyraja richardsonii*, representative of both sexes over a wide range of length classes, were secured during the 1997 longline (Connolly *et al.* 1998). A single specimen of *Bathyraja pallida*, which has been described from only two holotypes, was taken on this survey. Two recently described species *Hydrolagus pallidus* (Hardy and Stehmann, 1990) and *Raja kukujevi* (Dolganov, 1985) were also taken.

The FRC deep-water survey programme (1993 to 1997) has provided an insight into the deep-water ecosystem of the Rockall Trough in terms of providing limited information on discards, selectivity, general life history and records of unusual chondrichthian species. The direction of the survey programme will shift in the coming years towards commercial exploratory fishing surveys, the focus of which will be to develop new deep-water fisheries for species such as halibut, redfish and monkfish for the Irish fleet.

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Table 1 List of surveys from which data in this paper was obtained

Cruise code	Ship	Gear	Survey Type	No. Valid hau	Month	Year	Depth Range (m)	
MMIR130493	Mary M	Trawl	Research	48	April	93	201	915
MMIE300492	Mary M	Trawl	Exploratory	10	May	92	N/A	
MMIC130793	Mary M	Trawl	Commercial	4	July	93	476	1007
MMIC160893	Mary M	Trawl	Commercial	18	August	93	756	1098
SKIR020897	Skarheim	Longline	Research	32	August	97	292	2925
MMIC270795	Mary M	Trawl	Commercial	30	Aug/Sept	95	1273	1273
MMIE030992	Mary M	Trawl	Exploratory	8	September	92	630	1008
MMIR010993	Mary M	Trawl	Research	47	September	93	196	1168
MMIE030996	Mary M	Trawl	Exploratory	26	September	96	423	612
MMIR160996	Mary M	Trawl	Research	26	September	96	560	1102
MMIC291093	Mary M	Trawl	Commercial	10	October	93	N/A	
MMIR291097	Mary M	Trawl	Research	22	Oct/Nov	97	520	1158
MMIR011195	Mary M	Trawl	Research	26	November	95	740	1400
SSIR271195	Seasparkle	Longline	Research	22	Nov/Dec	95	542	1332

Table 2 Comparison of species caught and landed from trawling and longlining operations

Gear	Hours fished	Total catch (t)	Landed (t)	Discarded (t)
Trawl	669	236	143	93
Longline	445	35	28	7

Most common species in catch				Most common species in landings			
trawl	weight (t)	longline	weight (t)	trawl	weight (t)	longline	weight (t)
Coryphaenoides rupestris	92.4	Centrophorus squamosus	13.4	Coryphaenoides rupestris	88.9	Centrophorus squamosus	13.4
Alepocephalus bairdi	37.8	Daenia calceus	5.9	Aphanopus carbo	8.9	Centroscymnus coelolepis	5.1
Chimaera monstrosa	15.2	Centroscymnus coelolepis	5.3	Molva dypterygia	8.5	Brosme brosme	3.7
Argentina silus	10.9	Brosme brosme	3.7	Centroscymnus coelolepis	8.0	Mora moro	1.7
Aphanopus carbo	8.9	Mora moro	1.7	Lophius piscatorius	3.8	Daenia calceus	1.5
Squalidae	8.8	Etmopterus princeps	1.3	Phycis blennoides	3.5	Phycis blennoides	0.8
Molva dypterygia	8.6	Phycis blennoides	0.8	Merluccius merluccius	2.6	Centroscymnus crepidater	0.4
Centroscymnus coelolepis	8.2	Centroscymnus crepidater	0.6	Hoplostethus atlanticus	2.4	Etmopterus princeps	0.4
Centrophorus squamosus	8.1	Chimaera monstrosa	0.4	Centrophorus squamosus	2.3	Molva dypterygia	0.3
Daenia calceus	6.9	Molva dypterygia	0.3	Argentina silus	1.7	Molva Molva	0.3

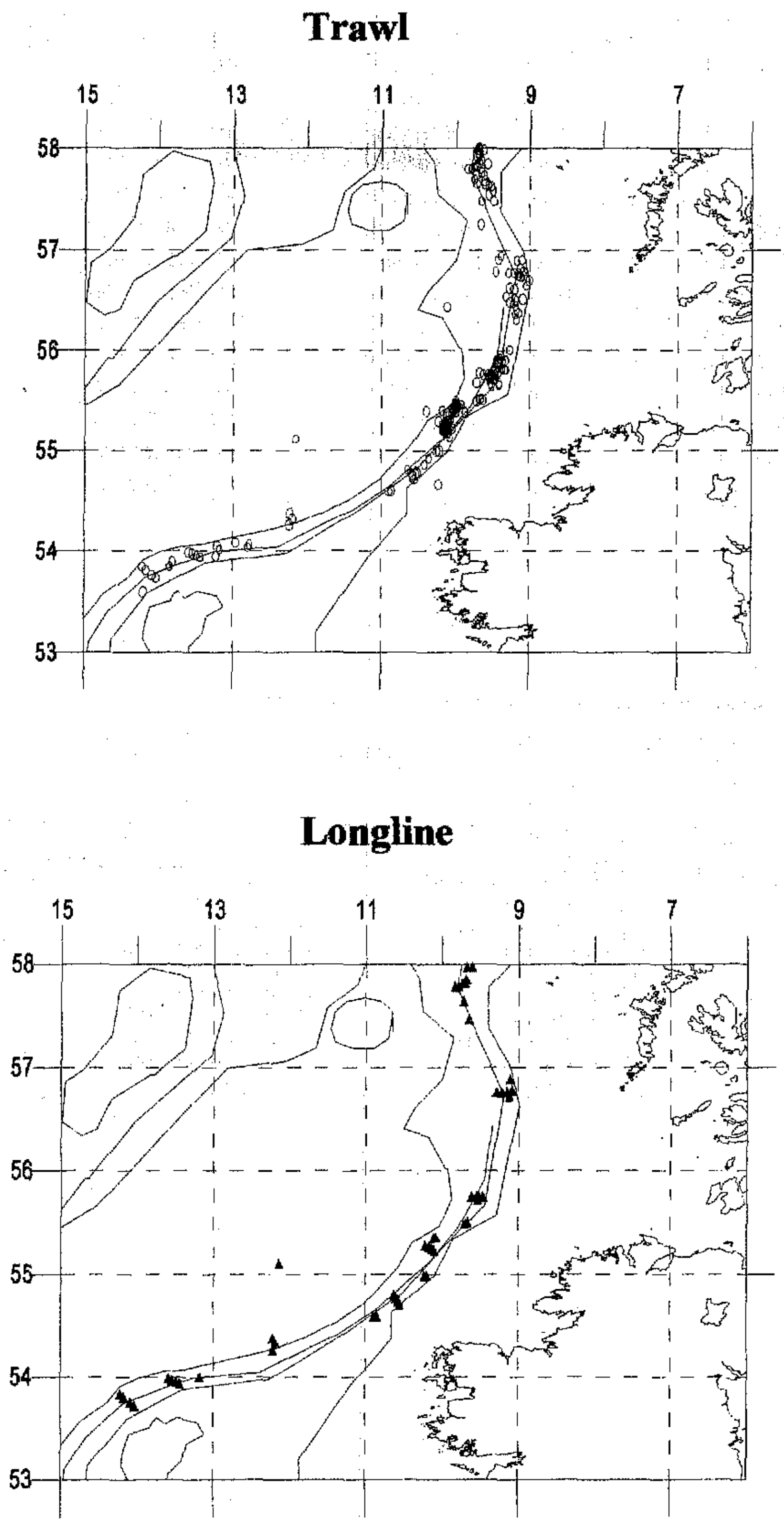

Fig 1 Maps showing the locations of trawl and longline fishing operations (open circles and closed triangles respecitvely) during the various surveys from 1992 to 1997 .

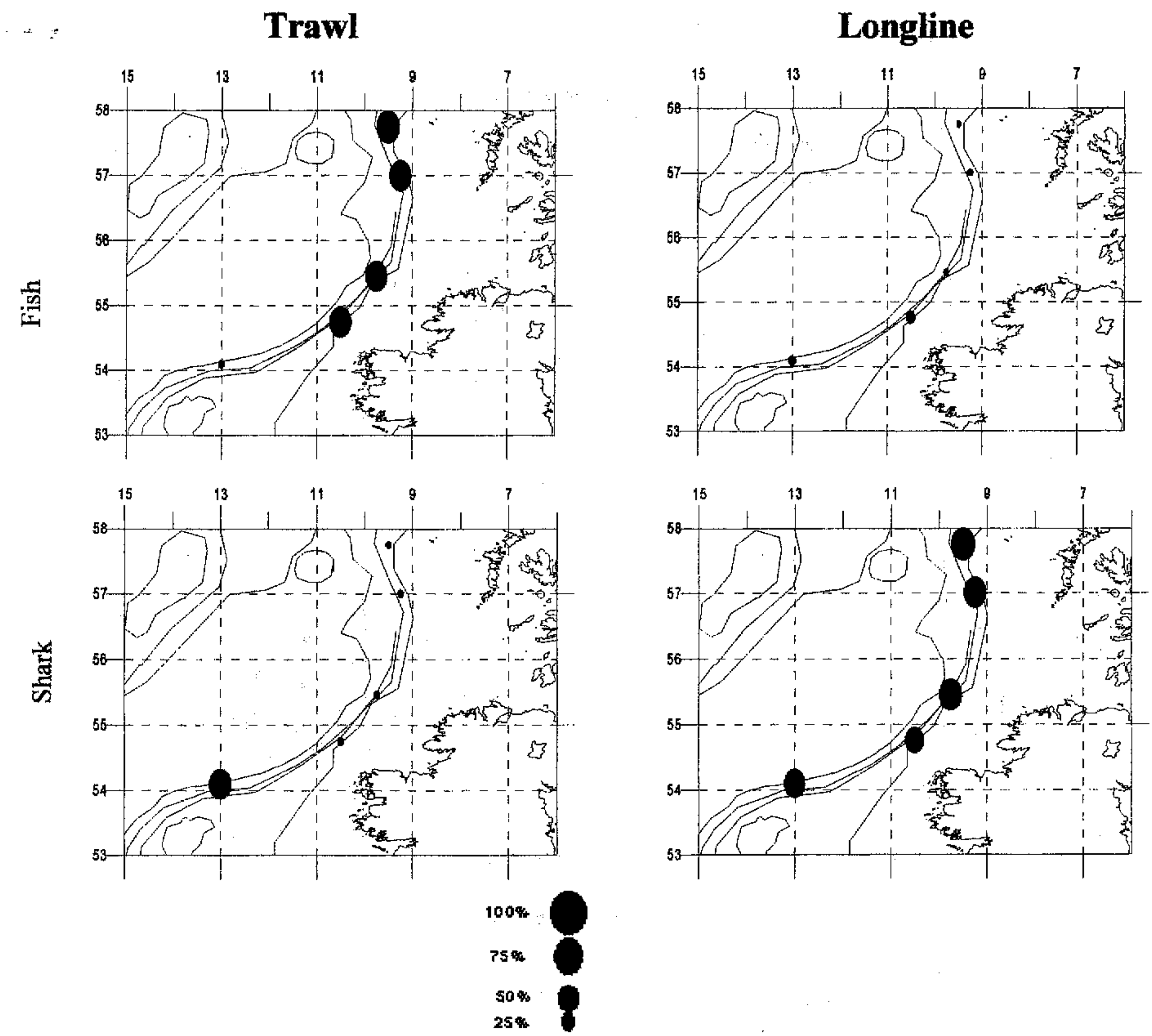

Fig.2 Comparison of catches of Shark (*Centrophorus squamosus, Centroscymnus coelolepis Deania calceus*) and fish (*Coryphaenoides rupestris Aphanopus carbo Phycis blennoides Helicolenus dactylopterus Molva dypterygia Brosme brosme*) from Trawls and Longlines compared. Each category of catch is expressed as a percentage of the total catch by that gear.

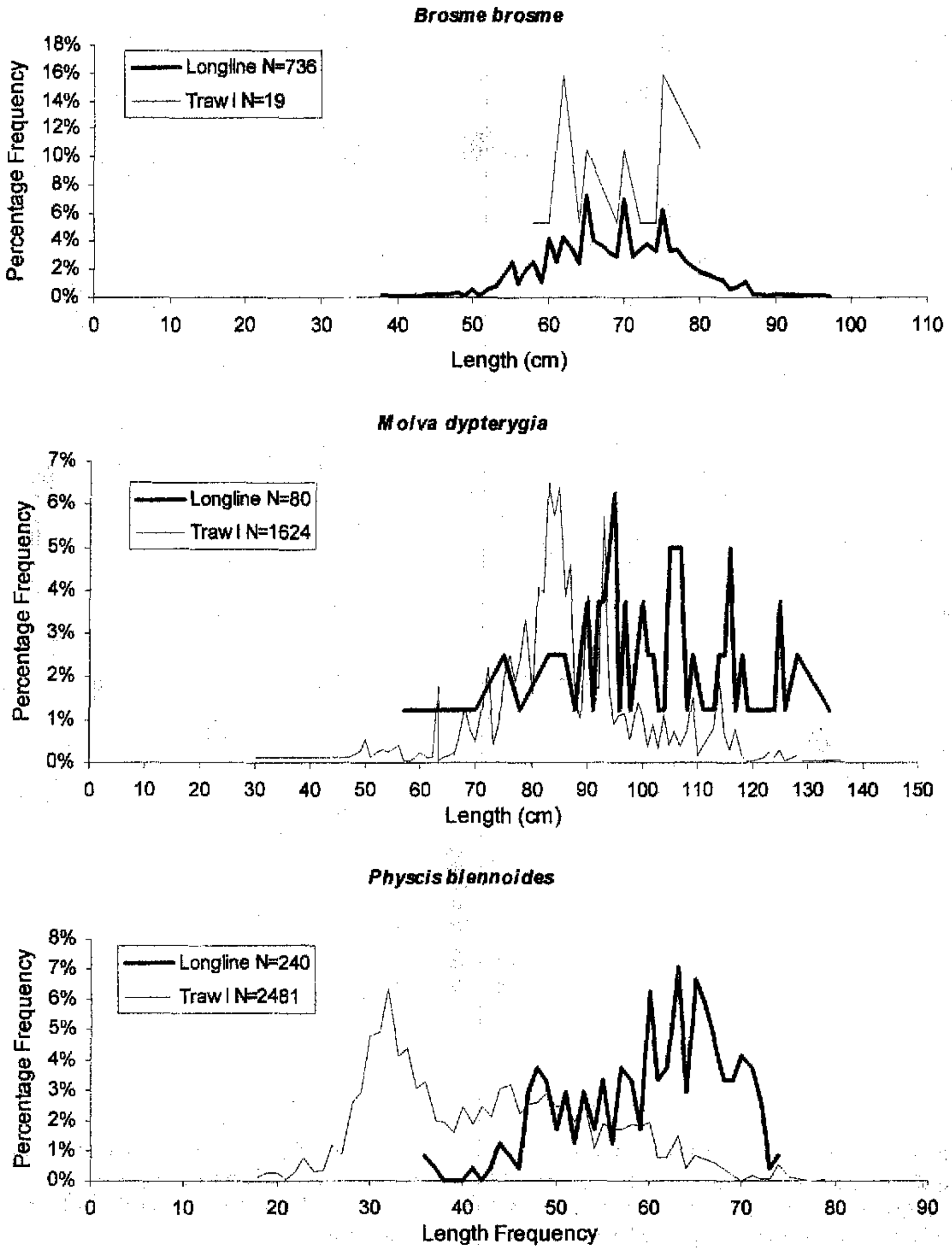

Figure 3 Length Frequency distribution of *Brosme brosme*, *Molva dypterygia*, and *Physcis blennoides* from trawl and longline survey data.

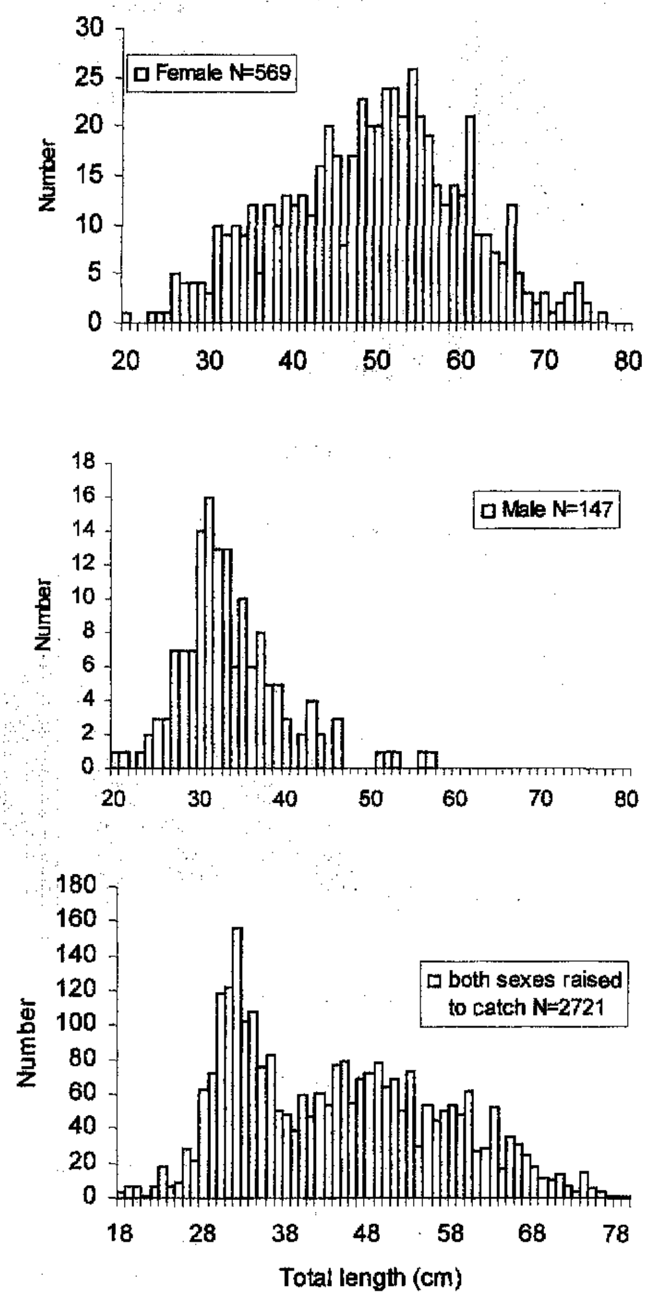

Fig. 4 Length frequency distributions of greater forkbeard by sex and from measured only data raised to the catch

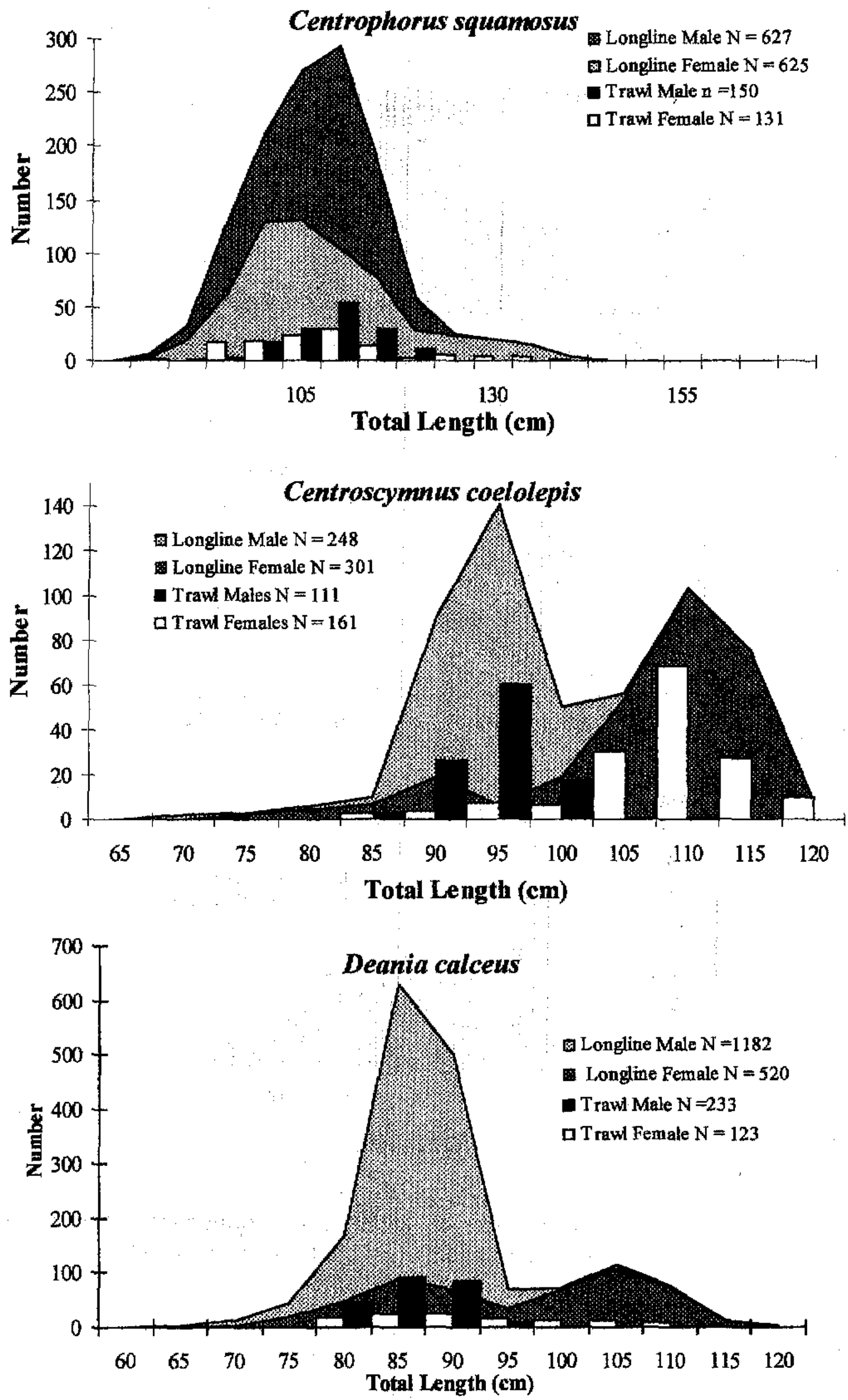

Fig. 5 Length frequency distributions of shark by sex from trawling and longlining

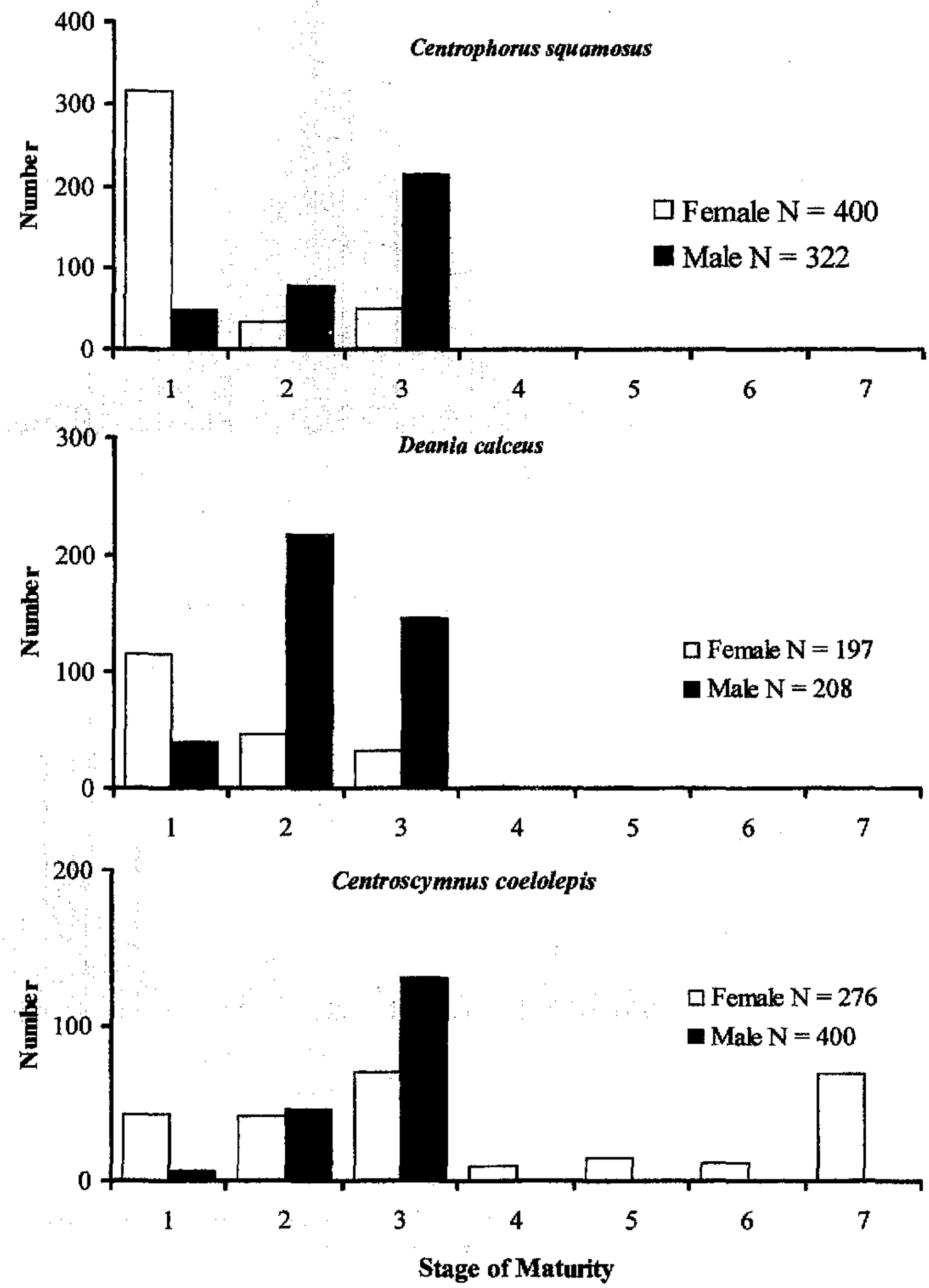

Fig. 6 Maturity stages of three squaloid shark species over the survey period (1992-1997)

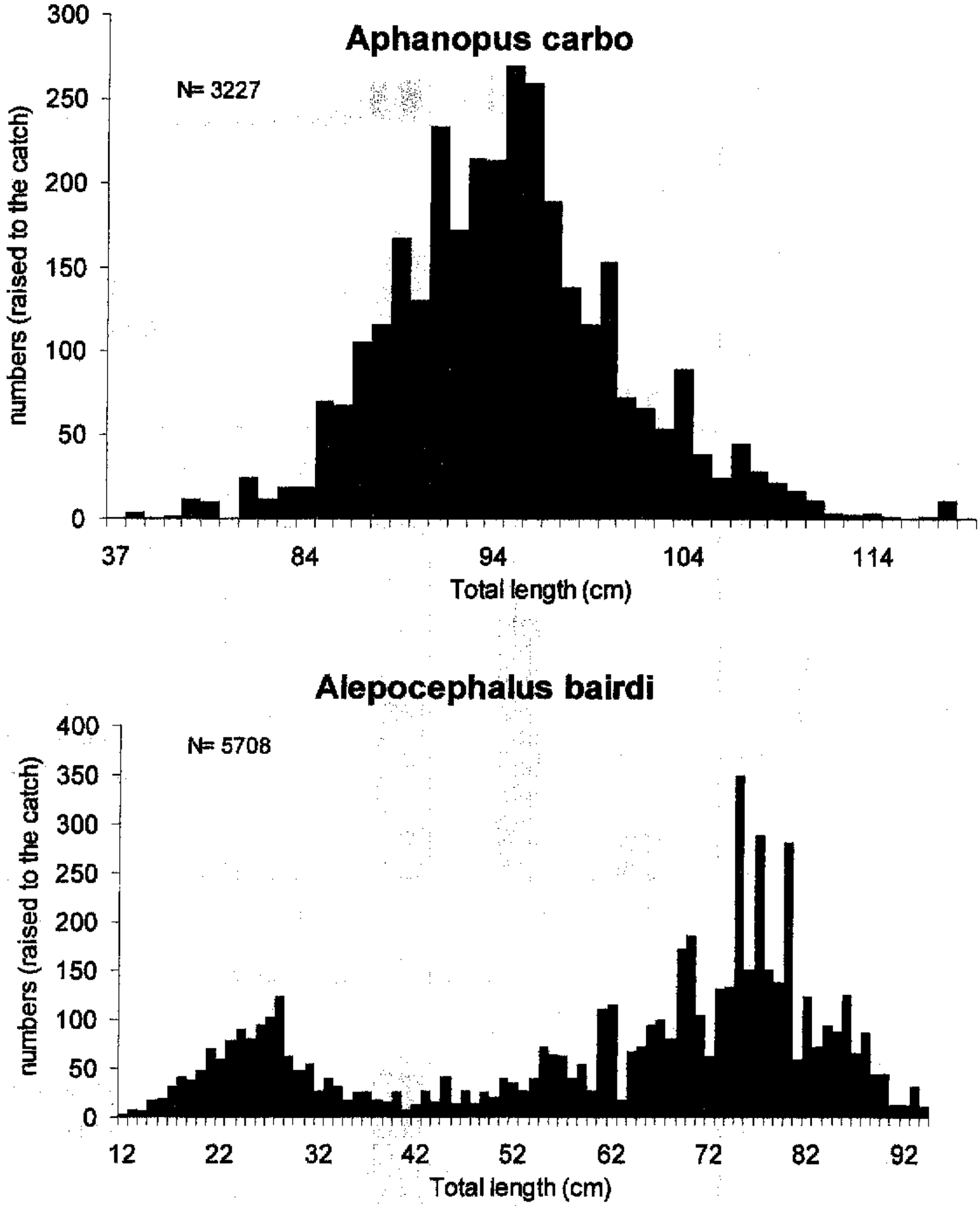

Figure 7 Length frequency distribution of bairds smootheads and black scabbard fish from the raised catches of all surveys conducted by the FRC during 1993-1997.

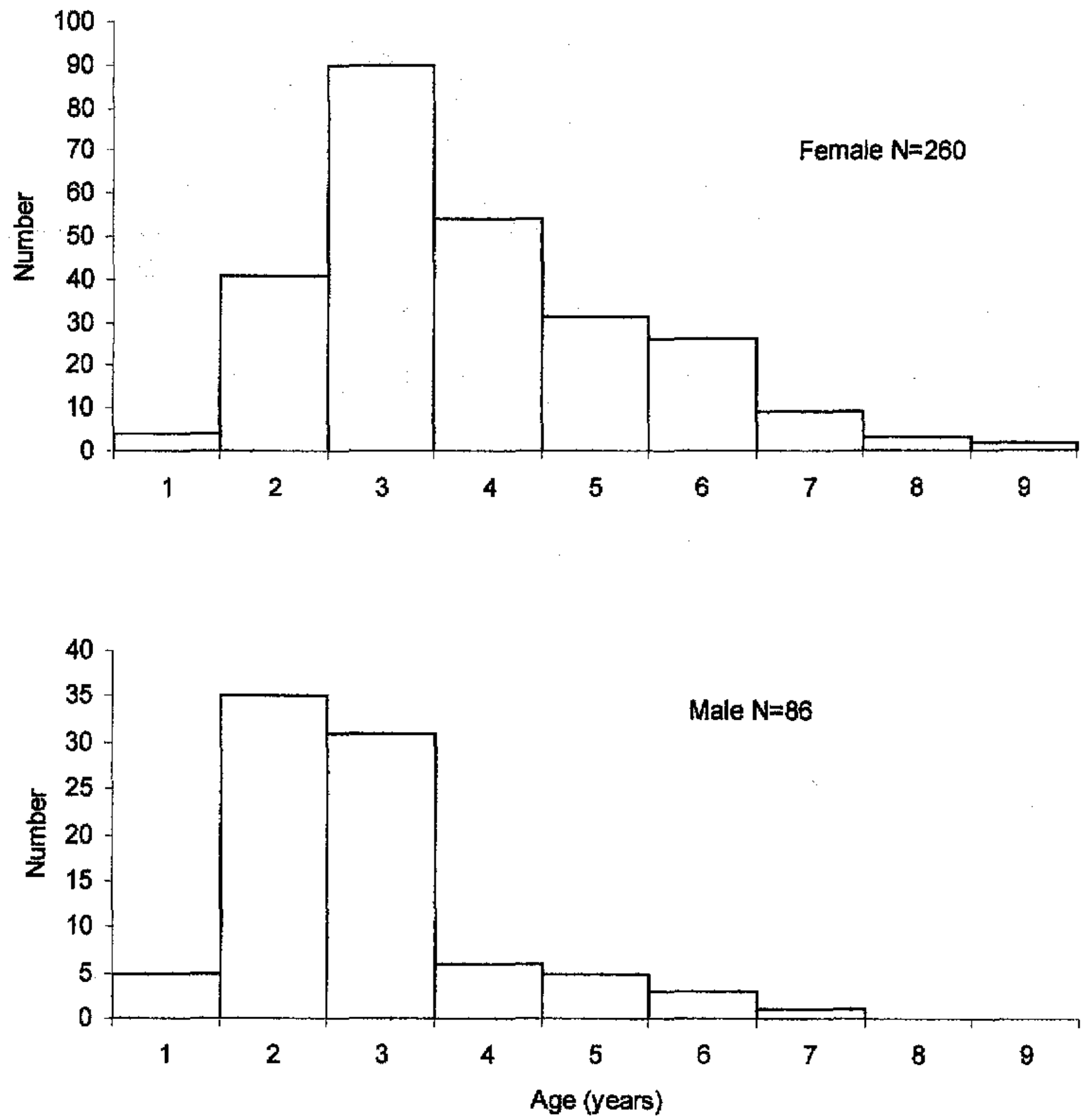

Fig.8 Age distribution of sampled forkbeard from all surveys (1992-1997)

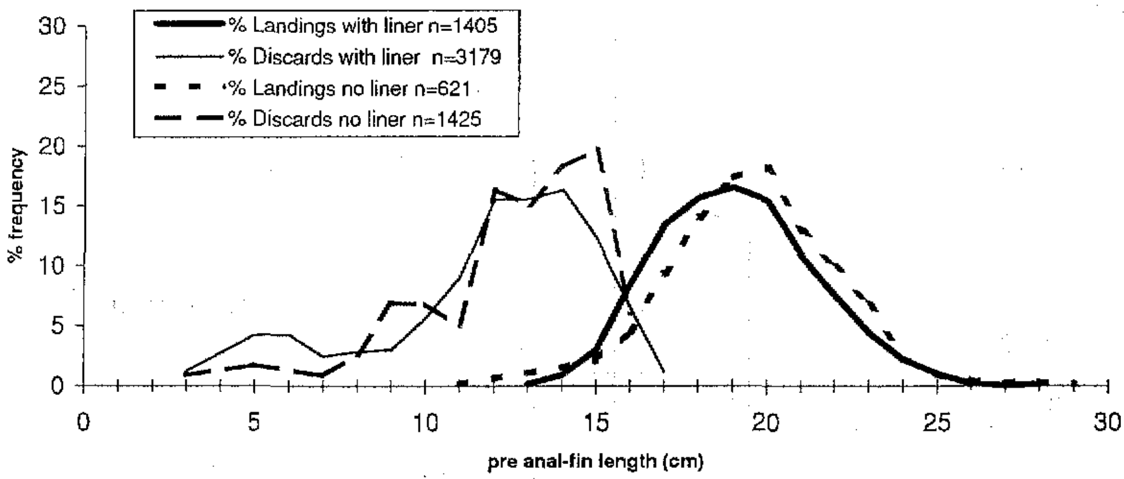

Fig.9 Length frequency of roundnose grenadier from a commercial trawl (100mm) with and without a small mesh cod end liner (25mm)